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(54) [Title of the Invention] Semiconductor Device

(57) [ABSTRACT]
[Object] In the case of conducting an anodic oxidation step for forming an oxide film for an electrode connected to a thin film transistor formed over the glass substrate, to provide a structure for preventing corrosion of the backside of the substrate caused by dissolution due to

an acid.
[Constitution] Protective films composed of insulating films are provided on one surface of a substrate over which the thin film transistor is provided and on the other surface.

[Scope of Claims]
[Claim 1] A semiconductor device characterized in that a thin film transistor is formed over a substrate, and protective films comprising insulating films are formed on one surface of the substrate over which the thin film transistor is provided and on the other surface.
[Claim 2] The semiconductor device according to Claim 1, characterized in that the insulating films comprises a silicon oxide.
[Claim 3] The semiconductor device according to Claim 1, characterized in that the insulating films comprises a silicon nitride.
[Claim 4] A semiconductor device characterized in that a thin film transistor is provided over a substrate, the thin film transistor has at least one electrode that is at least partially anodized, and films including a silicon oxide or a silicon nitride as their main component are formed on one surface of the substrate over which the thin film transistor is provided and on the other surface.
[Claim 5] A semiconductor device characterized in that a thin film transistor is provided over a substrate, the thin film transistor has at least one electrode that is at least partially anodized, and a film including a silicon oxide or a silicon nitride as its main component is formed on a surface of the substrate over which the thin film transistor is not provided.
[Detailed Description of the Invention]
[0001]
[Field of Industrial Application] The present invention relates to a semiconductor device that has an insulated gate thin film transistor (TFT) provided over a glass substrate and has an anodized electrode.
[0002]
[Prior Art] Conventionally, it is widely known to form a TFT (thin film transistor) for the purpose of driving active matrix liquid crystal display devices, image sensors, and the like.
[0003] This TFT is formed on a substrate with an insulating surface, such as a glass substrate. Further, for electrodes, particularly a gate electrode, a metal such as aluminum or tantalum is used, and the gate electrode has a film insulated with an oxide at the surface thereof.
[0004] In particular, for the oxide film, an anodic oxide film is often used which is formed by subjecting the electrode formed with the metal mentioned above as its main component to an anodic oxidation step. For the anodic oxidation step, there is one method in which a voltage of 10 to 200 V is applied to the electrode formed with the metal mentioned above as its main component in a chemical solution (electrolysis solution for performing anodic oxidation) containing a 3 to 10% of sulfuric acid, oxalic acid, chromic acid, tartaric acid, boric acid, or nitric acid to form an oxide film at the electrode surface. The film formed by anodic

oxidation in the acid or weak acid solution in this way has countless holes at the surface thereof, and is referred to as a porous anodic oxide film.

[0005] This step is employed in forming sidewalls of a gate electrode for a TFT. In addition, in the case of processing this anodic oxide by etching in a subsequent step, the gate electrode will be also etched when a phosphoric acid etchant is used as the etchant. Therefore, a barrier anodic oxide is formed on the gate electrode as well as at the side surfaces of the gate electrode to prevent the gate electrode from being etched. The barrier anodic oxide film is formed with the use of an aqueous solution or a neutral ethylene glycol chemical solution of a tartaric acid, a boric acid, a nitric acid, or an ammonium salt thereof. This film is a stable film that has a dense surface and electrically has a high withstand voltage.

[0006]

[Problem to be solved by the Invention] In manufacturing active matrix liquid crystal displays and image sensors that have a plurality of TFTs on a glass substrate surface, the backside of the glass substrate (the surface over which no TFT or the like is formed) is dipped in the chemical solution for a long time when an anodic oxide is formed at side surfaces of gate electrodes as described above. Therefore, at the time, corrosion caused by the acid, particularly sulfuric acid or oxalic acid reduces the transmission of the glass substrate, and significantly damages the smoothness of the backside of the substrate. As a result, the traveling direction of light is changed as compared with normal glass, and the problem of damage to display quality is caused in liquid crystal displays. Further, when the corrosion is developed, the substrate may be cracked, and the yield is thus reduced. This is caused because the acid solution or weak acid solution dissolves the substrate surface.

[0007] However, in order to conduct anodic oxidation so that the oxide film for the gate electrode or the like has a sufficient thickness, it is desirable to use the acid such as tartaric acid, nitric acid, or boric acid mentioned above.

[0008] In addition, in porous anodic oxidation, the attachment of a glass component dissolved in the chemical solution, which contains a lot of impurities, to the substrate surface leads to TFT electric characteristics, particularly increasing off resistance, and drift of the electric characteristics.

[0009] Therefore, it has been desired to prevent corrosion of the substrate due to anodic oxidation.

[0010] It is an object of the present invention, in the case of conducting an anodic oxidation step for forming an oxide film for an electrode connected to a thin film transistor formed over the glass substrate, to provide a structure for preventing corrosion of the backside of the substrate caused by dissolution due to an acid.

[0011]

[Means for Solving the Problem] A semiconductor device according to the present invention is characterized in that a protective film that has corrosion resistance against a chemical solution for anodic oxidation is formed on a surface of a substrate over which no thin film transistor is provided, or on one surface of the substrate over which a thin film transistor is provided and

the other surface (the surface over which no thin film transistor is provided).

[0012] FIG. 1 shows basic steps for forming a structure according to the present invention. First, protective films 102 are formed on surfaces of a substrate 101 by dipping, CVD, sputtering, vapor deposition, or the like. As the protective films, a silicon oxide, a silicon nitride, and the like that have only a small amount of impurities and have strong corrosion resistance against acids can be used. In addition, a silicon carbide film, a DLC (diamond-like carbon) film, and the like may be used. The protective films 102 appropriately have a thickness of 100 to 5000 Å, preferably about 300 to 2000 Å. These films are entirely or substantially entirely provided on the both surfaces of the glass substrate 101 or only on the surface over which no thin film transistor is to be formed. The formation of these films enables the backside of the substrate to be prevented from being corroded in a subsequent anodic oxidation step, whereby maintaining the smoothness.

[0013] Further, as shown in FIG. 5(a), the protective film 102 may be provided to enclose the entire surface including side surfaces (side edges) of the glass substrate 101, and a base insulating film 103 may be thereon as shown in FIG. 5(b). Alternatively, as shown in FIG. 6(a), a protective film 102 may be provided to enclose the surface over which no thin film transistor is to be formed and the side surfaces (side edges) of glass substrate 101, while no protective film is provided on the surface over which a thin film transistor is to be formed, and a base insulating film 103 may be thereon as shown in FIG. 6(b). In this way, the corrosion can be more surely prevented.

[0014] Next, a base insulating film 103 is formed on the substrate, and an active layer 104 composed of a crystalline semiconductor is further formed. It is to be noted that semiconductors with a bit of mixed crystalline region such as a single crystal, a polyscrystal, or a microcrystal are all referred to as crystalline semiconductors in the specification. Then, an insulating film 105 is formed with the use of a material such as a silicon oxide to cover this layer, and a film is further formed. As a material for this film, aluminum, tantalum, titanium, silicon, and the like that are able to be anodized are preferable.

[0015] Further, a film to serve as a mask in anodic oxidation is formed to cover the film, and the both films are simultaneously subjected to patterning and etching to form a gate electrode 106 and a mask film 107 thereon. As a material for this mask film, a photoresist used in a normal photolithography step, a photosensitive polyimide, or a normal polyimide that is able to be etched may be used (FIG. 1(A)).

[0016] Next, a porous anodic oxide 108 is formed at side surfaces of the gate electrode by applying an electric current to the gate electrode 106 in an electrolysis solution. This anodic oxidation step is carried out with the use of an acidic aqueous solution of 3 to 20% of citric acid or oxalic acid, phosphoric acid, chromic acid, sulfuric acid or the like. In this case, a thick anodic oxide of 0.5 μm or more can be formed at a low voltage of about 10 to 30 V (FIG. 1(B)).

[0017] Then, the insulating film 105 is etched by dry etching, wet etching, or the like, and after that, the anodic oxide 108 is removed. As the etchant, a phosphoric solution, for example, a

mixed acid of a phosphoric acid, an acetic acid, and a nitric acid is used. However, when the gate electrode is aluminum, the use of a phosphoric etchant etches the gate electrode at the same time. Therefore, in the previous step, a barrier anodic oxide 109 may be provided at the side surfaces and upper surface of the gate electrode by applying an electric current to the gate electrode in an aqueous solution or an ethylene glycol solution including a 3 to 10% of tartaric solution, boric acid, nitric acid, or ammonium salt thereof. In this anodic oxidation step, the thickness of the resultant anodic oxide is determined by the magnitude of the voltage applied between the gate electrode 106 and the opposed electrode (FIG. 1(C)).

[0018] For a semiconductor device according to the present invention, a gate electrode that has a single-layer structure may be used, or a gate electrode that has a multi-layer structure of two or more layers stacked may be used, which is for example, a two-layer structure of titanium silicide stacked on aluminum, or a two-layer structure of aluminum stacked on titanium nitride. The thickness of each layer may be determined by the practitioner, depending on required device characteristics.

[0019]

[Operation] It has been generally understood that glass is hardly corroded by acids. Therefore, a substrate is conventionally dipped in an acid solution at anodic oxidation without forming any film or the like on the substrate surface for preventing corrosion due to the acid.

[0020] However, the results of experiments by the inventors have found that the acid in the solution develops corrosion of glass to damage the smoothness of the substrate surface.

[0021] In the present invention, as a protective film, a material that is not easily dissolved in acids is used for a substrate surface to enable corrosion of the substrate surface to be prevented.

[0022]

[Embodiments]

[Embodiment 1] FIG. 1 shows the present embodiment. First, silicon oxide films 102 were formed on both surfaces of a substrate 101 (Corning 7059, 300 mm × 400 mm or 100 mm × 100 mm). As a method of forming this oxide film, the substrate was dipped in a SiO_2 coating solution for forming a film, such as OCD produced by Tokyo Ohka Kogyo Co., Ltd., and after that, the substrate was fired at a temperature of 250 to 500°C, preferably 450 to 500°C. The higher the firing temperature is, the higher the etching rate is. The etching rate at a firing temperature of 450°C is twice as high as at a temperature of 250°C.

[0023] Next, as shown in the figure, on the substrate 101, a silicon oxide film 1000 to 3000 Å in thickness was formed as a base oxide film 103. As a method of forming this oxide film, sputtering in an oxygen atmosphere was used.

[0024] At this point, as shown in FIG. 5(a), the protective film 102 may be provided to enclose the entire surface including side surfaces (side edges) of the glass substrate 101, and a base insulating film 103 may be thereon as shown in FIG. 5(b). Alternatively, as shown in FIG. 6(a), a protective film 102 may be provided to enclose the surface over which no thin film transistor is formed and the side surfaces (side edges) of glass substrate 101, while no

protective film is provided on the surface over which a thin film transistor is to be formed, and a base insulating film 103 may be thereon as shown in FIG. 6(b). In this way, the corrosion can be more surely prevented.

[0025] After that, an amorphous silicon film of 300 to 5000 Å, preferably 500 to 1000 Å was deposited by plasma CVD or LPCVD, and left in a reduction atmosphere at 550 to 600°C for 24 hours to be crystallized. Then, the thus crystallized silicon film was subjected to patterning to form an island-shaped region 104. Further, a silicon oxide film 105 of 700 to 1500 Å in thickness was formed thereon by sputtering.

[0026] After that, an aluminum (containing 1 wt% of Si, or 0.1 to 0.3 wt% of Sc (scandium)) film of 1000 Å to 3 μm in thickness was formed by electron beam evaporation or sputtering. Then, a photoresist (for example, OFPR800/30cp produced by Tokyo Ohka Kogyo Co., Ltd.) was formed by spin coating. The formation of an aluminum oxide film of 100 to 1000 Å in thickness at the surface by anodic oxidation before the formation of the photoresist resulted in favorable adhesion to the photoresist, and suppressed current leakage from the photoresist to be effective for forming a porous anodic oxide only at side surfaces in a subsequent anodic oxidation step. After that, the photoresist and the aluminum film were together subjected to patterning and etching to provide a gate electrode 106 and a mask film 107 (FIG. 1(A)).

[0027] Further, anodic oxidation was carried out by passing an electric current in an electrolysis solution (chemical solution) to form a porous anodic oxide 108 of 3000 to 6000 Å in thickness, for example, 5000 Å in thickness. The anodic oxidation may be carried out with the use of an acidic aqueous solution of 3 to 20% of citric acid or oxalic acid, phosphoric acid, chromic acid, sulfuric acid or the like, where a constant current at 10 to 30 V is applied to the gate electrode. In the present embodiment, the anodic oxidation was carried out at 10 V in an oxalic acid solution (30°C) for 20 to 40 minutes. The thickness of the anodic oxide was controlled by the anodic oxidation time (FIG. 1(B)).

[0028] After that, the silicon oxide film 105 was etched by dry etching. In this etching, a plasma mode of isotropic etching or a reactive ion etching mode of anisotropic etching may be used. However, it is important to increase the selectivity of silicon oxide to silicon sufficiently so that the active layer is not etched in the deep. For example, when CF_4 is used as the etching gas, the porous anodic oxide 108 is not etched, while only the silicon oxide film 105 is etched. In addition, the silicon oxide film 105' under the porous anodic oxide 108 was left unetched (FIG. 1(C)).

[0029] Next, an electric current was again applied to the gate electrode in an electrolysis solution. This time, an aqueous solution or an ethylene glycol solution including 3 to 10% of tartaric solution, boric acid, nitric acid, or ammonium salt thereof was used. Therefore, a barrier anodic oxide 109 was formed at the upper surface and side surfaces of the gate electrode. Since the thickness of the anodic oxide 109 is proportional to the applied voltage, an anodic oxide of 2000 Å was formed at an applied voltage of 150 V. Since a high voltage of 250 V or more is required to obtain an anodic oxide of 3000 Å or more in thickness, which will have adverse effects on TFT characteristics, it is preferable that the anodic oxide have a

thickness of 3000 Å or less. In the present embodiment, the voltage was increased to 80 to 150 V, which was selected depending on the required thickness of the anodic oxide 109 (FIG. 1(D)).

[0030] After that, the anodic oxide 108 was etched with the used of a mixed acid of a phosphoric acid, an acetic acid, and a nitric acid. In this etching, only the anodic oxide 108 was etched, and the etching rate was about 600 Å /minute. The underlying gate insulating film 105' was left without change. Then, an impurity was injected by ion doping into the active layer 104 for a TFT in a self-alignment manner with the gate electrode portion (i.e., the gate electrode and the surrounding anodic oxide film) and the gate insulating film as a mask to form low resistance impurity regions (source/drain electrodes) 111, 114 and high resistance impurity regions 111, 112. The use of phosphine (PH_3) as the doping gas resulted in N-type impurity regions. In order to form P-type impurity regions, diborane (B_2H_6) may be used as the doping gas. The dose amount and the acceleration energy were made to be 5×10^{14} to 5×10^{15} cm^{-2} and 10 to 30 keV, respectively. After that, KrF excimer laser (wavelength: 248 nm, pulse width: 20 nsec) irradiation was carried out to activate the impurity ions introduced in the active layer (FIG. 1 (E)).

[0031] Finally, as an interlayer insulator 115, a silicon oxide film of 3000 Å in thickness was formed on the entire surface by CVD. Contact holes were formed in the source/drain for a TFT, and aluminum wirings and electrodes 116, 117 were formed. Further, hydrogen annealing was carried out at 200 to 400°C. Thus, a TFT was completed (FIG. 1(F)).

[0032] FIG. 4(A) shows an example where a plurality of TFTs is formed over one substrate by means of the approach shown in FIG. 1. In this example, three TFTs 1 to 3 are formed. The TFT 1 and 2 are used as driver TFTs, where oxides 401, 402 corresponding to the anodic oxide 109 in FIG. 1 are made small in thickness, 200 to 1000 Å, for example, 500 Å so that a gate electrode and a high resistance region (HRD) are slightly overlapped with each other. The figure shows an example where the TFTs are adapted to serve as a CMOS inverter in such a way that a drain of the TFT1 and a source of the TFT2 are connected to each other, a source of the TFT1 is grounded, and a drain of the TFT2 is connected to a power source. There are various other peripheral circuits, and such a CMOS circuits may be provided in accordance with the respective specifications.

[0033] On the other hand, the TFT 3 is used as a pixel TFT, where an anodic oxide 403 is made thick, 2000 Å to suppress leakage current. One of source/drain electrodes of the TFT3 is connected to a pixel electrode 404 of an ITO. In order to give variety to the thicknesses of the anodic oxides in this way, the electrodes may be separated so that the voltages of the gate electrodes of the respective TFTs can be independently controlled. It is to be noted that the TFT1 and the TFT3 are N-channel TFTs while the TFT2 is a P-channel TFT.

[0034] [Embodiment 2] FIG. 2 shows the present embodiment. First, on a substrate 201 (for example, Corning 7059) with an insulating surface, protective films 202 composed of a silicon oxide were formed by a DIP method in order to prevent corrosion of the backside of the substrate from being caused due to a subsequent anodic oxidation step. At this point, as

shown in FIG. 5(a), the protective film 202 may be provided to enclose the entire surface including side surfaces (side edges) of the glass substrate 201, and a base insulating film 203 may be thereon as shown in FIG. 5(b). Alternatively, as shown in FIG. 6(a), a protective film 202 may be provided to enclose the surface over which no thin film transistor is formed and the side surfaces (side edges) of glass substrate 201, while no protective film is provided on the surface over which a thin film transistor is to be formed, and a base insulating film 203 may be thereon as shown in FIG. 6(b). In this way, the corrosion can be more surely prevented.

[0035] Next, a base oxide film 203, an island-shaped silicon semiconductor region (for example, a crystalline silicon semiconductor) 204, a gate insulating film 205, a gate electrode 206 of an aluminum film (2000 to 1 μm in thickness), and a porous anodic oxide (3000 Å to 1 μm in thickness, for example, 5000 Å) 207 at side surfaces of the gate electrode were formed over the substrate 201 by means of the steps (A) to (C) in Embodiment 1 (FIG. 2(A)).

Then, a barrier anodic oxide 208 of 1000 to 2500 Å in thickness was formed in the same way as in Embodiment 1 (FIG. 2(B)).

[0036] Further, with this barrier anodic oxide film 208 as a mask, the porous anodic oxide film 207 was removed by etching. After that, with the gate electrode portion (206, 208) and the gate insulating film 205 as a mask, impurity injection was carried out by ion doping to form low resistance impurity regions 209, 210 and high resistance impurity regions 210, 211. The dose amount and the acceleration voltage were made to be 1 to 5 × 10^{14} cm^{-2} and 30 to 90 kV. Phosphorus was used as the impurity (FIG. 2(C)).

[0037] Further, a film of an appropriate metal, for example, titanium, nickel, molybdenum, tungsten, platinum, palladium, or the like, for example, a titanium film 213 of 50 to 500 Å in thickness was formed by sputtering over the entire surface. As a result, the metal film (the titanium film in this embodiment) 214 was formed in close contact with the low resistance impurity regions 209, 212 (FIG. 2(D)).

[0038] Then, KrF excimer laser (wavelength: 248 nm, pulse width: 20 nsec) irradiation activated the impurity introduced by the doping, and reacted the metal film (titanium in this embodiment) with silicon of the active layer to form metal silicide (titanium silicide in this embodiment) regions 214, 215. The laser energy density was appropriately 200 to 400 mJ/cm^2, and preferably 250 to 300 mJ/cm^2. In addition, heating the substrate to 200 to 500°C during the laser irradiation was able to prevent separation of the titanium film.

[0039] After this, the Ti film was etched with an etching solution of hydrogen peroxide, ammonia, and water mixed at 5:2:2. The titanium film other than the portion in contact with the exposed active layer (for example, the titanium film on the gate insulating film 205 and the anodic oxide film 208), which is left in the metallic state without change, can be remove by this etching. On the other hand, the titanium silicide 214, 215 being a metal silicide is not etched, and thus allowed to remain (FIG. 2(E)).

[0040] Finally, as shown in FIG. 2 (F), a silicon oxide film of 2000 Å to 1 μm in thickness, for example, 3000 Å was formed by CVD as an interlayer insulator 218 over the entire surface,

contact holes were formed in the source/drain for a TFT, and aluminum wirings and electrodes 219, 220 were formed to have a thickness of 2000 Å to 1 μm, for example, 5000 Å. In the present embodiment, it is the titanium silicide that is in contact with the aluminum wirings, and the stability of the interface between the titanium silicide and the aluminum is better than the case of silicon. Therefore, contact with high reliability was obtained. In addition, when, for example, a titanium nitride is formed as a barrier metal between the aluminum electrodes 219, 220 and the silicide regions 214, 215, the reliability can be even more improved. In the present embodiment, the sheet resistances of the silicide regions were 10 to 50 Ω/□, while the sheet resistances of the high resistance impurity regions 210, 211 were 10 to 100 kΩ/□. As a result, a TFT with favorable frequency characteristics and less hot-carrier degradation even at high drain voltages was able to be manufactured.

[0041] FIG. 4(B) shows an example where a plurality of TFTs is formed over one substrate by means of the approach shown in FIG. 2. In this example, three TFTs 1 to 3 are formed. The TFTs 1 and 2 as driver TFTs are used in a CMOS configuration, an inverter configuration in this embodiment, where oxides 405, 406 corresponding to the anodic oxide 208 in FIG. 2 are made small in thickness, 200 to 1000 Å, for example, 500 Å for slight overlapping. On the other hand, the TFT 3 is used as a pixel TFT, where an anodic oxide 407 is made 2000 Å thick in offset to suppress leakage current. One of source/drain electrodes of the TFT3 is connected to a pixel electrode 408 of an ITO. In order to give variety to the thicknesses of the anodic oxides in this way, the electrodes may be separated so that the voltages of the gate electrodes of the respective TFTs can be independently controlled. It is to be noted that the TFT1 and the TFT3 are N-channel TFTs while the TFT2 is a P-channel TFT.

[0042] Although the step of forming the titanium film is arranged after the step of the ion doping in the present embodiment, these steps may be conducted in reverse order. In such a case, the entire surface covered with the titanium film during ion irradiation has a profound effect on prevention of abnormal charge (charge up) which has been a problem with an insulating substrate. In addition, after the ion doping and then annealing by means of laser or the like, the titanium film may be formed, and laser irradiation, thermal annealing, or the like may be carried out to form titanium silicide.

[0043] [Embodiment 3] FIG. 3 shows the present embodiment. First, on both surfaces of a substrate (Corning 7059) 301, protective films 302 composed of a silicon oxide were formed by CVD. At this point, as shown in FIG. 5(a), the protective film 302 may be provided to enclose the entire surface including side surfaces (side edges) of the glass substrate 301, and a base insulating film 303 may be thereon as shown in FIG. 5(b). Alternatively, as shown in FIG. 6(a), a protective film 302 may be provided to enclose the surface over which no thin film transistor is to be formed and the side surfaces (side edges) of glass substrate 301, while no protective film is provided on the surface over which a thin film transistor is to be formed, and a base insulating film 303 may be thereon as shown in FIG. 6(b). In this way, the corrosion can be more surely prevented.

[0044] Next, a base oxide film 303, an island-shaped crystalline semiconductor region, for

example, a silicon semiconductor region 304, a gate insulating film 305, a gate electrode 306 of an aluminum film (2000 Å to 1 μm in thickness), and a porous anodic oxide (6000 Å in thickness) 307 at side surfaces of the gate electrode were formed over the substrate 301 by means of the steps (A) to (C) in Embodiment 1 (FIG. 3(A)).

Then, a barrier anodic oxide 308 of 1000 to 2500 Å in thickness was formed in the same way as in Embodiment 1 (FIG. 3(B)).

[0045] Further, the porous anodic oxide 306 was selectively etched to expose a portion of the gate insulating film 305. After that, an appropriate metal, for example, a titanium film 309 of 50 to 500 Å in thickness was formed by sputtering over the entire surface (FIG. 3(C)).

[0046] Then, KrF excimer laser (wavelength: 248 nm, pulse width: 20 nsec) irradiation reacted the titanium with silicon of the active layer to form titanium silicide regions 309, 310. The laser energy density was appropriately 200 to 400 mJ/cm^2, and preferably 250 to 300 mJ/cm^2. In addition, heating the substrate to 200 to 500°C during the laser irradiation was able to prevent separation of the titanium film. This step may be carried out by lamp annealing of visible light irradiation or near-infrared light irradiation.

[0047] After this, the Ti film was etched with an etching solution of hydrogen peroxide, ammonia, and water mixed at 5:2:2. The titanium film other than the portion in contact with the exposed active layer (for example, the titanium film on the gate insulating film 305 and the anodic oxide film 308), which is left in the metallic state without change, can be remove by this etching. On the other hand, the titanium silicide 310, 311 being a metal silicide is not etched, and thus allowed to remain (FIG. 3(D)).

[0048] After that, with the gate electrode portion and the gate insulating film 305 as a mask, impurity injection was carried out by ion doping to form low resistance impurity regions (titanium silicide regions) 312, 315 and high resistance impurity regions 313, 314. The dose amount and the acceleration voltage were made to be 1 to 5 × 10^{14} cm^{-2} and 30 to 90 kV. Phosphorus was used as the impurity (FIG. 3(E)).

[0049] Then, KrF excimer laser (wavelength: 248 nm, pulse width: 20 nsec) irradiation again activated the impurity introduced by the doping. This step may be carried out by lamp annealing of visible light irradiation or near-infrared light irradiation. Finally, with the gate electrode portion (306, 308) as a mask, the gate insulating film 305 was etched. This etching was carried out in order to avoid instability due to the impurity introduced by the doping into the gate insulating film 305. As a result, the gate insulating film 304' was left only under the gate electrode portion.

[0050] Then, as shown in FIG. 3(F), a silicon oxide film 600 nm in thickness was formed by CVD as an interlayer insulator 316 over the entire surface, contact holes were formed in the source/drain for a TFT, and aluminum wirings and electrodes 317, 318 were formed. Thus, a TFT was completed.

[0051]

[Effect of the Invention] The present invention enables corrosion of the substrate in an anodic oxidation step to be prevented, and a TFT substrate can be thus manufactured with a high yield.

More specifically, the present invention enables prevention of corrosion due to sulfuric acid or oxalic acid used for porous anodic oxidation, and damage to the smoothness of the substrate backside as glass is thus eliminated. As a result, the problem of damage to display quality in liquid crystal displays due to change in traveling direction of light is not caused, or the substrate is not cracked at all due to development of corrosion.

[0052] In addition, in anodic oxidation, the attachment of a glass component dissolved in the chemical solution to the substrate surface conventionally leads to TFT electric characteristics, particularly increasing off resistance. However, such a problem can be also prevented by providing a protective film according to the present invention, the electric characteristics are thus stabilized, and even a polysilicon TFT comparable to an amorphous Si TFT in off resistance can be achieved.

[0053] Furthermore, the strength of the substrate itself can be improved.

[Brief Description of the Drawings]

[FIG. 1] showing a method for manufacturing a TFT according to Embodiment 1

[FIG. 2] showing a method for manufacturing a TFT according to Embodiment 2

[FIG. 3] showing a method for manufacturing a TFT according to Embodiment 3

[FIG. 4] showing examples of integrated circuits of TFTs obtained according to Embodiments 1 and 2

[FIG. 5] showing a diagram of a protective film enclosing side surfaces (side edges) of a glass substrate

[FIG. 6] showing a diagram of a protective film enclosing surfaces other than a surface over which a TFT is to be formed

[Explanation of the Reference Numerals and Signs]

101, 201, 301	insulating substrate
102, 202, 302	protective film
103, 203, 303	base oxide film
104, 204, 304	active layer
105, 205, 305	insulating film
105', 305'	gate insulating film
106, 206, 207, 306, 308	gate electrode (aluminum)
107	mask film
108, 207, 307	anodic oxide (porous aluminum oxide)
109, 208	anodic oxide (barrier aluminum oxide)
110	gate insulating film edge
111, 114, 209, 211, 312, 315	low resistance impurity region
112, 113, 210, 212, 313, 314	high resistance impurity region
115, 218, 316	interlayer insulating film
116, 117, 219, 220, 317, 318	metal wiring, electrode
213, 309	titanium film
214, 215	metal silicide

401, 402, 403, 405, 406, 407	anodic oxide
404, 408	pixel electrode

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